The Effect of a Simulation Training Package on Skill Acquisition for Duplex Arterial Stenosis Detection

Usman Jaffer, PhD, Pasha Normahani, MBBS, Prashant Singh, BSc, Mohammed Aslam, PhD, and Nigel J. Standfield, MD

Department of Vascular Surgery, Imperial College School of Medicine, Hammersmith Hospital, London, United Kingdom

OBJECTIVES: In vascular surgery, duplex ultrasonography is a valuable diagnostic tool in patients with peripheral vascular disease, and there is increasing demand for vascular surgeons to be able to perform duplex scanning. This study evaluates the role of a novel simulation training package on vascular ultrasound (US) skill acquisition.

MATERIALS AND METHODS: A total of 19 novices measured predefined stenosis in a simulated pulsatile vessel using both peak systolic velocity ratio (PSVR) and diameter reduction (DR) methods before and after a short period of training using a simulated training package. The training package consisted of a simulated pulsatile vessel phantom, a set of instructional videos, duplex ultrasound objective structured assessment of technical skills (DUOSATS) tool, and a portable US scanner. Quantitative metrics (procedure time, percentage error using PSVR and DR methods, DUOSAT scores, and global rating scores) before and after training were compared.

RESULTS: Subjects spent a median time of 144 mins (IQR: 60-195) training using the simulation package. Subjects exhibited statistically significant improvements when comparing pretraining and posttraining DUOSAT scores (pretraining = 17 [16-19.3] vs posttraining = 30 [27.8-31.8]; $p < 0.01$), global rating score (pretraining = 1 [1-2] vs posttraining = 4 [3.8-4]; $p < 0.01$), percentage error using both the DR (pretraining = 12.6% [9-29.6] vs posttraining = 10.3% [8.9-11.1]; $p = 0.03$) and PSVR (pretraining = 60% [40-60] vs posttraining = 20% [6.7-20]; $p < 0.01$) methods.

CONCLUSION: In this study, subjects with no previous practical US experience developed the ability to both acquire and interpret arterial duplex images in a pulsatile simulated phantom following a short period of goal direct training using a simulation training package. A simulation training package may be a valuable tool for integration into a vascular training program. However, further work is needed to explore whether these newly attained skills are translated into clinical assessment. (J Surg 72:310-315. Crown Copyright © 2014 Published by Elsevier Inc. on behalf of the Association of Program Directors in Surgery. All rights reserved.)

KEY WORDS: ultrasound, duplex, simulation, training, vascular

COMPETENCIES: Medical Knowledge, Practice-Based Learning and Improvement, Systems-Based Practice

INTRODUCTION

Traditionally, ultrasound (US) imaging has primarily been the work of radiologists. However, with the advent of point-of-care ultrasonography, there has been much debate regarding the dissemination of diagnostic US into other specialities to overcome the limitation in service provision and ensure timely access to care. The use of US as a diagnostic tool for surgeons has been demonstrated to be feasible in clinical practice, e.g., trauma (FAST scan),[1] aortic US,[2] and gall bladder US.[3] Current evidence suggests that surgeon-performed USs are safe, economical, and acceptable to patients.[4,5] Recognizing this growing niche, the Royal College of Radiologists has issued guidelines for training in the medical and surgical specialities.[6]

In vascular surgery, duplex ultrasound (DUS) is a valuable diagnostic tool and is being increasingly utilized as a first-line investigation in the assessment of carotid and peripheral vascular disease.[7] Point-of-care DUS may also be potentially useful in certain scenarios, such as an acutely ischemic limb where rapid ascertainment of blood flow is necessary. Increasing demand for vascular surgeons to perform duplex scanning is reflected in the inclusion of

Correspondence: Inquiries to Usman Jaffer, BSc (Hons), MSc (Surgery), MSc (Ultrasound), PGCE, PhD, FRCS, Department of Vascular Surgery, Imperial College School of Medicine, Hammersmith Hospital, Du Cane Road, London W12 0HS, UK; fax: (208) 383-2083; e-mail: usman.jaffer@doctors.org.uk

  1931-7204/$30.00 http://dx.doi.org/10.1016/j.jsurg.2014.09.013

basic knowledge and practical skills in the new vascular surgery curriculum.[8] As suggested by a recent study on a group of novice vascular trainees, as little as 50 examinations of the above-knee arterial tree and 100 examinations of the below-knee arterial tree may be required to gain competence, well within the reach of a surgical trainee.[9]

To address limitations of traditional apprenticeship training and restrictions in the time available to trainees, simulation-based US training is beginning to develop and gain enthusiasm.[10] However, there has been little such development in the field of vascular US.

The purpose of this study was to evaluate the role of a novel simulation training package on vascular US skill acquisition in a group of medical learners with no or limited vascular or stenosis detection experience.

MATERIALS/METHODS

A total of 19 novice subjects were recruited and consented to participate in the study; ethical approval was not required.

Training Package

A training package consisting of a simulated in vitro pulsatile vessel phantom, a set of instructional videos, and an arterial duplex ultrasound (DUS)–specific assessment tool was developed and used in conjunction with a portable US scanner (Mindray M7, Shenzhen, China).

The simulated model consisted of a high-fidelity pulsatile-flow simulator (Axiom Medical Ltd, London; Fig. 1), which forces pulses of blood mimicking solution through a simulated vessel arranged in a tissue "phantom." This allows any pathological/physiological arterial waveform to be simulated. A straight vessel with an adjustable degree of stenosis was used.

Performance was evaluated using the Duplex Ultrasound Objective Structured Assessment of Technical Skills (DUOSATS) tool (Fig. 2). DUOSATS was developed based on the established Objective Structured Assessment of Technical Skills (OSATS) scale[11] and has been previously validated.[12] For these simulator-based assessments, a modified DUOSATS was used; this did not count the patient positioning and reporting fields. A score of 22 of a possible 34 is the cutoff point in determining competence.[12]

All participants were shown a standardized instructional video prepared at our institution that incorporated the principles of vascular US, the apparatus being used, and the correct technique of duplex arterial stenosis measurement using both the diameter reduction (DR) and peak systolic velocity ratio (PSVR) assessments. PSVR assessment involves obtaining the ratio of the maximal peak systolic velocity at the stenosis to that away from the stenosis. DR assessment involves obtaining the ratio of residual lumen diameter to what would have been the diseased luminal diameter. The total duration time of the video was 6 minutes and 45 seconds. A link to the video has been provided (Appendix 1).

FIGURE 1. Flow simulator and single-vessel tissue phantom, Axiom Medical Ltd.

Study Protocol

All participants were shown the standardized instructional video. Following this, they were given 10 minutes to familiarize themselves with the portable US machine. Questions regarding the functioning of the US machine and simulator were answered. The subjects were then asked, in the presence of an assessor (P.S.), to measure a predefined stenosis in the simulated vessel, under femoral artery flow conditions using both PSVR and DR methods and record their estimated values. The participants were blinded to the actual stenosis value. Video recordings of each attempt were made for later analysis.

The participants were then given the opportunity to practice their skills on the simulated model for a maximum of 3 hours. During this time, they were allowed to watch the instructional videos as many times as they wished. Once the subject felt sufficiently confident in the desired skill, they were asked to repeat the original assessment. All procedures took place in the Vascular Laboratory at Hammersmith Hospital.

Following the completion of the study, the video recordings were evaluated using the DUOSATS assessment tool, by 2 specialists (U.J. and M.A.) in vascular US (>4 years practical experience) who were blinded to the study and not involved in data collection.

Data Collection

Total procedure times were measured using a stopwatch. The percentage errors for both PSVR and DR assessments were calculated against the actual grade of stenosis. The directionality of the error was ignored.